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IRRIGATION RETURN FLOW STUDY WAPATO
IRRIGATION DISTRICT YAKIMA RIVER BASIN,
WASHINGTON

Public Health Service
Portland, Oregon

May 1964

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WORKING PAPER NO. 47

COLUMBIA RIVER BASIN PROJECT
For Water Supply and Water Quality Management

IRRIGATION RETURN FLOW STUDY
WAPATO IRRIGATION DISTRICT
YAKIMA RIVER BASIN
WASHINGTON

DATE: May 1964

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Prepared by WEB & WAM

Project Staff _____

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U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Region IX

Division of Water Supply and Pollution Control
570 Pittock Block
Portland 5, Oregon

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This working paper contains preliminary data and information primarily intended for internal use by the Columbia River Basin staff and cooperating agencies. The material presented in this paper has not been fully evaluated and should not be considered as final.

IRRIGATION RETURN FLOW STUDY
WAPATO IRRIGATION DISTRICT
YAKIMA RIVER BASIN
WASHINGTON

ABSTRACT

A study of return flows in the Wapato Irrigation District in the Yakima River Basin in central Washington was made during the 1963 irrigation season to determine effects of the (principally) irrigation use on water quality. Parameters investigated included temperature, oxygen demand, hardness, turbidity, coliform bacteria, pesticide toxins, and various nutrient ions. Some degradation of quality was observed for nearly every parameter, but the overall effect was not severe. The chief recommendations for improvement of water quality involve improvements in amount and timing and method of application of the irrigation water, and a continuing educational safety campaign on use of pesticides.

THE STUDY

INTRODUCTION

This study was initiated in the spring of 1963 to develop information needed for planning the protection and management of water resources and water quality in arid portions of the Columbia River Basin. The area selected for study lies near the center of the basin and typifies much of the irrigated crop and pasture land of the basin.

The study was aimed at determining the kinds and amounts of chemicals applied to the land, the kinds and amounts of chemicals removed from the land by irrigation return flows, and at determining how to minimize any adverse effects through modification of land use and irrigation practices.

SCOPE

The study covered the Wapato Irrigation District on the Yakima Indian Reservation in southwestern Yakima County in central Washington, including 136,000 acres of irrigable area of which about 118,000 acres were irrigated during the period of the study. Duration of the study was from the beginning of one irrigation season in spring up to the beginning of the next.

The study included obtaining information on water intake and return flow, based on measurements reported from the three supply sources and nine principal drains; on area devoted to various classes of crops; and on the use of fertilizers and pesticides for each crop. It involved field measurement of intake and drain temperature and pH; and collection of water samples for determination of BOD and COD, ammonia and nitrate nitrogen, phosphate, chloride, sulfate, bicarbonate, sodium, and potassium ion concentration;

turbidity, total solids and suspended solids, hardness, color, chlorophyll A and B content, coliform bacteria counts, and chlorinated hydrocarbon pesticides. It also involved interviews with agricultural chemical salespeople, irrigation district managers, and county extension agents; as well as "library research" on Census of Agriculture and Bureau of Reclamation reports.

STUDY AREA CHARACTERISTICS

The Wapato Irrigation District covers the flat to very slightly rolling alluvial-filled valley in the central Yakima Basin, lying on the south and west of the Yakima River and including the lower parts of the tributary drainages of Toppenish and Satus Creeks. Part of the irrigation water source is from these two streams, but the major part comes from a large diversion from the Yakima River. The climate is characterized by scattered light winter and spring rainstorms, and long, hot, dry summer and fall seasons. Winters are relatively mild, with some snow at times. Average annual rainfall is about ten inches, so that irrigation is necessary for most crops.

In 1962 the land use was as follows, according to the Bureau of Reclamation statistics, and was not believed to have changed much in 1963.

Pasture	7,000 acres
Farmsteads, roads, ditches	<u>11,000</u>
<u>Not in irrigation rotation</u>	18,000 acres
Fallow, idle, not harvested	16,000 acres
Pasture	23,000
Hay and silage	20,000
Cereal grains	17,000
Field crops (sugar beets, mint, hops)	21,000
Vegetables	11,000
	(4,000 multiple-cropped)
Seeds	4,000
Orchard fruits	<u>6,000</u>
<u>In irrigation rotation</u>	<u>118,000 acres</u>
TOTAL	136,000 acres

Intake of water (diversion from the Yakima River and from Toppenish and Satus Creeks) for use on the irrigated areas averaged about five and one-quarter feet depth during the six months from April to September, inclusive; of this, an equivalent of about two feet depth was discharged as return flow in the drains.

<u>Flow in the intakes:</u>	<u>Code name:</u>
New Reservation Canal	WAP
Old Reservation Canal	(not sampled)
Toppenish Creek	TOP
Satus Creek	SAT

and in the return flow drains:Code name:

East Toppenish Drain	Eto
McDonald (Sub-drain 35)	Mcd
Marion (main) Drain	Mar
Toppenish Creek at Indian Church Road	Tci
Satus Creek at Highway 3A	Sc3
South Drain	Sou
Coulee Drain	Cou
Satus Drain 302	302
Satus Drain 303	303

was as follows in the 1963 irrigation season April to September, inclusive:

Table 1. Wapato Irrigation Project Flow Data, 1963

Item	Total flow by months, M acre-feet					
	April	May	June	July	Aug.	Sept.
Inflow to project ^{1/}	77.4	122.8	127.7	120.9	111.5	84.4
Outflow from project ^{2/}	<u>72.2</u>	<u>47.6</u>	<u>29.2</u>	<u>32.1</u>	<u>36.4</u>	<u>36.6</u>
Difference	5.2	75.2	98.5	88.8	75.1	47.8

^{1/} From the four diversions listed above.

^{2/} From the nine drains listed above.

The sum of the differences for the season is about equal to the irrigation application plus losses from the distribution system. There is no way to estimate influent or effluent seepage, and there is some inherent error in the flow measurements, so that it is difficult to strike a close balance. Precipitation during the irrigation season was slightly heavier than the normal two-and-a-half inches in the 1963 season, but still was not great enough to significantly affect soil moisture.

Inflow characteristics were as follows:

Table 2. Wapato Irrigation Project Inflow Water Quality

Item	Average Characteristics for Irrig. Season						
	pH	BOD	COD	Hardness (as CaCO ₃)	Turbidity	Susp. Solids	Dissolved Solids
Main Canal ^{1/}	7.0	1.4	7.9	42	4	16	90
Toppenish Creek ^{2/}	7.0	0.9	6.9	47	4	8	120
Satus Creek ^{3/}	7.3	1.0	6.3	47 ^{4/}	2.5	7	106

^{1/} Diverted from the Yakima River; already somewhat enriched and reused "second-hand" water.

^{2/} Fairly pure mountain runoff little enriched by land use or developments above the diversion point.

^{3/} Mountain runoff somewhat enriched by drainage from grazing lands and a few farmsteads above the diversion point.

^{4/} Would have been several points lower except for one very high value of 120 on the last sampling.

The averages do not tell the entire story; the range in intake pH, for example, was from 6.6 to 8.1, and was slightly higher at the beginning and end of the season than during the main irrigation period. In similar fashion, BOD varied from 0.1 to 3.9, with the higher values late in the season. The 3.9 value was for the November sample from Satus Creek. The COD also covered quite a range, from 2.0 to 19.2; but both the high and low values appeared to be scattered more or less at random over the period of record. For hardness, the averages are representative; except for the one high value footnoted in the table, there was little variation, although there is a tendency toward higher values late in the season. Turbidity ranged from 1 to 12, apparently at random. Total suspended solids ranged from 0 to 35, again apparently at random. Dissolved solids ranged from 20 to 193, with higher values in middle and late season.

For the drains, the picture is considerably different, as the following table shows:

Table 3. Wapato Irrigation Project Drain Water Quality

Item	Average Characteristics for Irrig. Season						
	pH	BOD	COD	Hardness (as CaCO ₃)	Turbidity	Susp. Solids	Dissolved Solids
<u>Drain</u>							
E. Toppenish	6.8	2.1	8.7	105	10	24	187
McDonald	7.1	1.8	7.6	110	5	27	195
Marion	7.4	1.4	7.2	116	5	18	219
Toppenish Creek	7.4	1.3	8.6	123	6	18	231
Satus Creek	7.4	1.2	8.1	112	6	40	225
South	7.3	1.1	8.6	123	13	55	241
Coulee	7.4	1.8	10.9	182	12	60	363
Satus 302	7.8	2.0	14.8	94	62	477	226
Satus 303	7.9	1.8	9.1	101	27	136	182

The range in pH for the drains, from 6.8 to 8.4 is the same as the range for the water sources, and is similar in being high early and late and low in midseason. The range in BOD, from 0.4 to 5.2, is wider than that for the intakes, and shows no pattern. The range in COD, from 3.4 to 24.9, is similar to that for the intakes, with the high values early in the season. Hardness of the water in the drains averages three to four times as great as in the intakes, and is considerably more variable, ranging from an early season low of 30 to a late season high of 317. Turbidity and suspended solids also were much higher in the drains, particularly in 302 and 303 at the lower end of the system where outfall erosion has been observed from time to time. Total dissolved solids content in the drains represented about double that in the intakes, was more variable, and showed the same trend of a gradual increase toward late season.

The units of measurement are the customary ones--logarithm of the hydrogen ion concentration for pH; milligrams per liter (units of weight per unit of volume, but in this case practically equivalent to parts per million) for BOD, COD, hardness, suspended solids, and dissolved solids; and Hellige turbidimeter units for turbidity. It is not, however, necessary to know the units to make an immediate comparison between conditions in the intake water and in that in the drains.

Various ions occurred as follows:

Table 4, Wapato Irrigation Project, Principal Non-carbonate Ions

Item	Average Characteristics for Irrigation Season					
	NH ₃ ⁺	NO ₃ ⁻	PO ₄ ⁻	Cl ⁻	SO ₄ ⁻	Na ⁺
<u>Intake</u>						
Main Canal	0.05	0.09	0.10	1.9	3.5	6.0
Toppenish Creek	0.04	0.06	0.17	0.8	0.8	6.0
Satus Creek	0.04	0.44 ^{1/}	0.21 ^{2/}	1.2	1.0	6.3
<u>Drain</u>						
E. Toppenish	0.38	1.46	0.66	4.2	6.8	11.7
McDonald	0.06	1.16	0.18	5.7 ^{3/}	8.0	13.0
Marion	0.06	0.82	0.24	4.2 ^{3/}	10.3	19.3
Toppenish Creek	0.06	0.36	0.24	5.5 ^{3/}	11.9	23.5
Satus Creek	0.04	0.45	0.23	5.0 ^{3/}	10.8	19.7
South	0.07	0.83	0.30	4.5	12.2	22.5
Coulee	0.08	0.72	0.47	7.5 ^{3/}	53.8 ^{4/}	50.5 ^{5/}
Satus 302	0.11	0.49	0.32	3.0	7.5	13.8
Satus 303	0.07	1.15	0.24	4.5	17.1	16.4

Units of measurement are milligrams per liter.

^{1/} Average would have been 0.02 except for high readings of 2.00 and 3.06 for which there is no explanation.

^{2/} Average would have been 0.09 except for one high reading of 1.53 for which there is no explanation.

^{3/} Includes at least one high value between 10.0 and 26.0.

^{4/} Includes three readings over 110.0 late in the season.

^{5/} Includes three readings between 80.0 and 100.0.

There was a considerable range in NH₃ in the drains, from 0 (several readings in all drains) to a high of 2.65 on one occasion in the East Toppenish drain; while the intakes showed little variation, with readings from 0 to 0.14 only. The drains did show an increase to nearly double the intake values, with some tendency toward higher values early in the season.

For NO_3 the picture is considerably different. Intake readings were generally low, from 0 in several instances to a high of 3.06 (but less than 0.30 90 percent of the time), and showed no pattern. Values reported for the drains averaged several times higher, ranged from 0 (one reading) to 4.06, and showed a tendency to be higher late in the irrigation season.

The PO_4 values for intake waters were generally below 0.30, with only two readings greater. If there was any pattern, it involved a slight decrease from the beginning of the season. The drains showed a slight increase toward the end of the season, and averaged about twice as high as the intakes. The range of values observed was somewhat greater for the drains, 0.05 to 2.25, than for the intakes.

It is with regard to Cl and SO_4 ions that the Yakima River intake shows its relative enrichment; it has twice the amount of Cl and four times the SO_4 found in the other two intakes. In the water in the drains, Cl was increased about three times; and SO_4 from two to ten times (excluding three very high end-of-season readings in Coulee Drain). For neither intakes nor drains did there appear to be any seasonal pattern nor any wide variation, except as footnoted, for Cl or for SO_4 .

Greatest uniformity in intake loading was found with Na ; the variation being within limits of 3.6 to 12.6. The drains average from two to eight times higher Na content than the intakes, with somewhat less uniformity. No seasonal trends appear in either.

Certain aspects of enrichment or pollution of the irrigation return flows showed definite trends with the season, or showed a very wide range of variation, or are otherwise sufficiently important to be treated in detail. In the first group is temperature. The temperatures observed during the season are shown in the table on Page 7.

Through the first half of the season the Wapato intake is warmest; this is Yakima River water already reused, and previously warmed. In the second half the Satus Creek intake is warmest; this is a stream with low flow running through a hot, dry valley above the diversion point. The intakes were warmest in August and early September. Temperature measurements were made between 9 a.m. and noon in most cases.

The drains warmed up earlier, and showed their highest temperatures from mid-June to August. The warmest drains were the two lowermost on the system; these carried the return flow from the warmest of the intakes. If the Wapato intake temperature is taken as representative of main Yakima River temperature, the drains are about five degrees centigrade warmer early in the season, six degrees higher in mid-season, but only about three degrees higher late in the season. From April through September, the return flows definitely increase temperatures in the main river over those in the intakes; though what corresponding increase would take place in the main river without diversion is not known. The maximum observed temperatures were over 25°C on four readings, reaching 26.5°C in one case, a little more than optimum for the aquatic habitat.

Table 5. Wapato Irrigation Project, Water Temperature, °C 1/

Station Date	INTAKES			DRAINS							
	WAP	TOP	SAT	Eto	Mcd	Mar	Tci	Sc3	Sou	Cou	302 303
4/15/63	7.9	7.6	9.3	14.8	14.0	11.7	12.5	9.7	12.5	dry	14.2 13.6
4/24	8.5	6.5	-	12.0	12.5	11.0	14.0	10.2	-	-	-
5/27	12.5	10.8	13.0	17.0	17.0	15.5	20.0	19.8	18.5	20.5	23.8 22.3
6/17	17.5	12.0	18.0	18.0	18.5	19.0	22.5	22.0	22.0	20.0	25.5 26.5
7/1	17.0	12.0	16.0	18.0	18.0	18.0	20.0	20.0	20.0	19.0	26.0 22.0
7/15	16.1	11.1	17.8	16.7	17.8	17.8	21.1	20.0	21.1	20.0	25.0 22.2
8/19	20.0	14.5	17.0	18.0	17.0	18.0	20.0	18.5	20.8	20.0	21.3 21.3
9/9	15.6	15.6	21.2	19.0	21.2	20.1	18.4	15.6	21.2	-	-
9/23	16.0	14.0	17.0	17.0	17.0	17.0	19.0	19.0	19.0	18.0	20.0 20.0
10/14	15.0	11.0	12.0	16.0	16.0	15.0	15.0	16.0	16.0	16.0	dry 16.0
11/12	-	9.0	14.0	13.0	14.0	9.0	10.0	12.0	12.0	11.0	dry dry
1/15/64	dry	7.0	2.0	11.0	10.0	8.0	2.0	5.0	dry	6.0	dry dry

1/ To convert: °C = 5/9(°F-32), or °F = 9/5 °C+32.

Coliform bacteria content of the intakes and drains alike rose to a peak at mid-season, though the load in the drains was many times greater than in the intakes. The variation from station to station and time to time was very great, so that it is difficult to find any pattern. The counts observed are given in the table on Page 9.

For the second half of the season, both total coliforms and fecal coliforms were determined. The peak total coliform count of 2,000,000 was associated with a fecal coliform count of 120,000; but a later total count of 250,000 was associated with a fecal count of 125,000. In most cases the ratio between them was much greater; but no good correlation is evident. The coliform count is not necessarily related to agricultural practices, as some meat-processing and vegetable-packing plants empty their wastes into the drains.

The picture with respect to pesticides is spotty. Most of the observations were zero; and the highest was less than $1\frac{1}{2}$ parts per billion. Only the halogenated hydrocarbon pesticides (the more persistent type) were checked; no attempt was made to analyze for the widely used organic phosphate compounds such as malathion and parathion and diazinon and toxaphene. Since pesticide use amounts to from one to three pounds per acre annually, not much appears to be carried away in the return flow. Occurrence of observations early in the season indicates that movement of pesticide toxins in return flows follows soon after application, as most application is early. The table on Page 10 shows results of the sampling and analysis for pesticides.

One odd value is the very early high record for Satus Creek intake on April 15. This may have been material carried from a forest spray project in the upper Satus watershed the preceding summer, when $\frac{3}{4}$ pound of DDT per acre was applied to several thousand acres infested with the spruce budworm.

The scattered occurrences noted for pesticide occurrence in the water samples would lead to the inference that with such infrequent sampling as was used, much larger "slugs" of pesticide may have been missed. "Accidents" such as washing spray equipment in irrigation canals, dumping leftover chemicals into drains, or drift of spray fog and dust over canals and drains, all have happened in this area. Any of them could create temporarily a highly toxic situation in the water as the "slug" of chemical moves through the system. However, the observations made are probably indicative of normal runoff without any accidental spills.

One other item studied was the occurrence of chlorophyll. Results of sampling and analyses for chlorophyll are shown in the table on Page 11.

Values observed were high early in the season; low in middle and late season, though showing a slight rise in August. The early highs may be due to plant material brought down by snowmelt high flow and by flushing of canals unused over winter; but the rise in August when the waters are warmest may have resulted from algal blooms. Early in the season there appeared to be slightly more chlorophyll A than chlorophyll B; but this situation was reversed through the middle of the season. Late in the season there was much more chlorophyll A than chlorophyll B.

Table 6. Wapato Irrigation Project, Total Coliform Bacteria in Water Samples ^{1/}

Station Date	INTAKES			DRAINS								
	WAP	TOP	SAT	Eto	Mcd	Mar	Tcd	Sc3	Sou	Cou	302	303
4/15/63	1,800	50	4	130	420	690	680	470	120	dry	10	1,900
5/27	1,260	200	210	13,000	3,900	1,900	70	270	1,600	2,700	4,200	54,000
6/17	6,400	4,500	5,500	49,000	-	13,000	35,000	12,000	38,000	85,000	80,000	300,000
7/1	2,300	76,000	3,700	280,000	65,000	112,000	120,000	122,000	250,000	93,000	105,000	300,000
7/15	10,600	9,100	6,400	82,000	21,000	23,000	46,000	24,000	47,000	180,000	280,000	105,000
8/19	22,000	43,000	31,000	150,000	39,000	39,000	120,000	2,000,000	80,000	70,000	160,000	79,000
9/9	21,000	5,700	19,000	250,000	17,000	2,800	1,800	2,500	1,200	-	-	-
9/23	200,000	15,000	800	180,000	16,000	12,000	19,000	5,000	9,000	10,000	-	23,000
10/14	18,000	1,000	800	24,000	2,500	2,400	3,200	1,600	1,200	5,300	dry	3,500
11/12	230	430	11,000	4,600	930	930	390	930	1,500	2,400	dry	dry

^{1/} Count per 100 milliliters.

Table 7. Wapato Irrigation Project, DDT and Other Chlorinated Hydrocarbon
Pesticides Found in Water Samples, in Parts per Trillion

Station Date	INTAKES			DRAINS								
	WAP	TOP	SAT	Eto	Mcd	Mar	Tci	Sc3	Sou	Cou	302	303
4/15/63	50	0	900	0	0	-	0	0	0	dry	0	0
4/24	50	50	50	T	T	T	120	T	120	-	80	100*
5/27	75	50	110	150	175	110	80	120	40	40	40	40
6/17	0	0	0	0	0	0	0	0	0	0	740** (700)	0
7/1	50	200	T	0	T	170	100	0	0	50	400	140
7/15	0	0	0	50	100	0	0	0	0	0	1,400**	T
8/19	0	0	0	0	0	0	0	0	57	55	45	0
9/9	0	0	0	350	0	T	0	0	0	0	-	-
9/23	0	** T****	0	T***	0	0	0	T****	T**	0	T**	0
10/14	T***	0	0	70***	0	0	0	0	0	0	dry	T
11/12	0	0	0	0	0	0	-	-	-	0	dry	dry
1/15/64	dry	0	0	T***	0	T**	0	0	dry	0	dry	dry

* Aldrin
** Dieldrin
*** Heptachlor
**** Chlordane

Table 8. Wapato Irrigation Project, Chlorophyll A and B Content of
Water Samples in Milligrams per Cubic Meter

Station Date	INTAKES			DRAINS							
	WAP	TOP	SAT	Eto	Mcd	Mar	Tci	Sc3	Sou	Cou	302 303
4/15/63	19.3	2.0	45.2	-	14.6	14.6	18.6	39.2	11.3	dry	7.9 24.4
4/24	-	-	-	-	-	-	-	-	-	-	-
5/27	5.1	1.8	1.8	6.3	5.1	3.6	1.8	5.1	10.4	5.1	12.6 6.3
6/17	7	3.4	4	4	7	7	7	15	7	-	12 7
7/1	0.28	0.14	0.14	2	2.78	8.46	14.97	6.27	-	1.91	6.69 8.14
7/15	1	0.36	0.65	1.29	0.65	1.20	1.65	2.01	1.20	3.79	4.39 1
8/19	20.28	0	14.98	24.18	20.16	25.33	13.24	34.54	5.18	8.06	8.06 20.16
9/9	2.65	1.84	2.65	2.39	1.84	2.26	3.05	-	0.92	-	-
9/23	3.97	0.36	0.54	0.36	1.26	4.14	5.46	5.40	2.65	2.13	2.24 2.93
10/14	5.73	0.91	1.46	2.21	2.57	4.37	3.97	7.39	6.94	13.48	dry 8.20
11/12	-	-	-	-	-	-	-	-	-	-	-
1/15/64	-	-	-	-	-	-	-	-	-	-	-

CONCLUSIONS

Though the water returned to the river from the irrigated land of the Wapato project is greatly enriched compared to its quality incoming, the enrichment does not amount to a severe degradation of water quality. The principal degradation relates to increases in coliform bacteria, though the high-count occurrences were random and irregular and were not correlated with any observed condition. Somewhat the same situation holds for pesticides; a few samples with high enough toxic content to be dangerous to some forms of aquatic insects were collected, but the highest concentration found was only one and a half parts per billion. This is not believed to present a hazard to livestock or to people. However, as noted, with such infrequent sampling it is very probable that much higher concentrations were missed; the only cause for joy lies in the fact that most of the observations showed zero pesticide content.

RECOMMENDATIONS

The difficulty in getting accurate measurements of water, in establishing a "water balance" for the project area, and in determining the actual water use by the crops as separate from the various losses, all point to the need for development of improved measuring systems. This is, however, somewhat outside the scope of the present study and report.

Despite the competition for markets and for water to grow the crops to send to the markets, there undoubtedly are various ways in which water use can be made more efficient both in terms of volume and quality of crop production and in terms of water loss or wastage. Changes in timing and amount of each irrigation application, and in methods of application, may result both in improved crop yield and in reduction of total water use.

Contracts between processors and growers specify method and timing of various cultural operations, including fertilization, irrigation, and pesticide application. These specifications comprise a rather tight system of control; as they are accepted by more and more farmers, they lower the hazard to water resources from incidental contamination either by excess nutrients or by toxins. But a continuing educational effort--and safety campaign--are needed to prevent the accidental contamination from spills, thoughtless washing of spray equipment in drains, etc.

Bacterial contamination is a different matter. Where it is due to waste discharge from meat packing plants, it can be reduced by lagooning wastes until the period of biological degradation is over before release of effluent to the drains. But where it is due to ground-water movement from septic tank disposal fields on the individual farms, not much improvement can be gained until a complete sewage system for the entire irrigation district can be installed. This is exceedingly unlikely in the foreseeable future.

APPENDIX
LABORATORY ANALYSES

Summary

Table 1. Sampling Points

Table 2. Tabulations of Data from Laboratory Analyses

SUMMARY

The individual results presented in Table 2 leave very little from which to draw conclusions. The variations between stations and also the variations within the same station throughout the year can be expected. From the data, the following conclusions can be drawn:

1. The month of April shows a consistently higher algal growth as indicated by the concentration of chlorophyll A and B found. Some evidence of a secondary algal growth is shown in September 1963 in stations Cou and below. In April, the NO_3 and PO_4 concentrations are also low, which might be contributory to the high algal growth. However, it will be noted that during September these low concentrations of NO_3 and PO_4 do not hold for all stations.

2. The maximum BOD found of 5.2 mg/l occurred at station Cou on April 24. On this date, the maximum COD of 24.9 was also obtained. As will be noted, in the previous sampling period on April 15, no water was flowing in this drain. It is likely, therefore, that the high results obtained on the 24th were due to the flushing action of the irrigation return flow. This is the only sampling point on this drain which combines with the South Coulee drain before entering the Yakima River. It should be pointed out that a BOD of 5.2 mg/l (the highest obtained) would be considered good according to Eastern standards. Nevertheless, this must be considered as high in the Columbia River Basin system; but, if flushing was the cause, then the results can be ignored since the dilution in the Yakima River should be able to handle this load. The remainder of the BOD values obtained at the other stations and at this station throughout the remainder of the sampling period show no significant domestic filtration.

Of the approximately 150 BOD values obtained, only six showed a BOD of 3.0 and higher. These six values were scattered among the various sampling stations over the period, April 24 to November 11. This again indicates a lack of severity of domestic pollution.

3. It will be noted that the NO_3 and PO_4 values are higher in summer. This can be accounted for by the wash-off of fertilizers and the natural decomposition of organic material which would account, especially, for the high nitrate values.

In summary, it may be stated that, as far as the results obtained from the Wapato project are concerned, there does not appear to be any cause for alarm from irrigation return water.

TABLE 1
SAMPLING POINTS

<u>Code</u>	<u>Description</u>
WAP	Wapato Irrigation Canal at State Hwy. 3A just below the point of diversion from the Yakima River
TOP	Toppenish Creek near White Swan above the major diversions
SAT	Satus Creek at lowermost U.S. Hwy. 97 bridge
Eto	East Toppenish Drain at Parton Road
McD	McDonald Drain (Sub-Drain 35) at Parton Road
Mar	Marion (Main) Drain at Indian Church Road
Tci	Toppenish Creek at Indian Church Road
Sc3	Satus Creek at State Hwy. 3A
Sou	South Drain at State Hwy. 3A
Cou	Coulee Drain (North Satus Road)
302	Drain 302 (State Hwy. 3A)
303	Drain 303 (Looney Road)

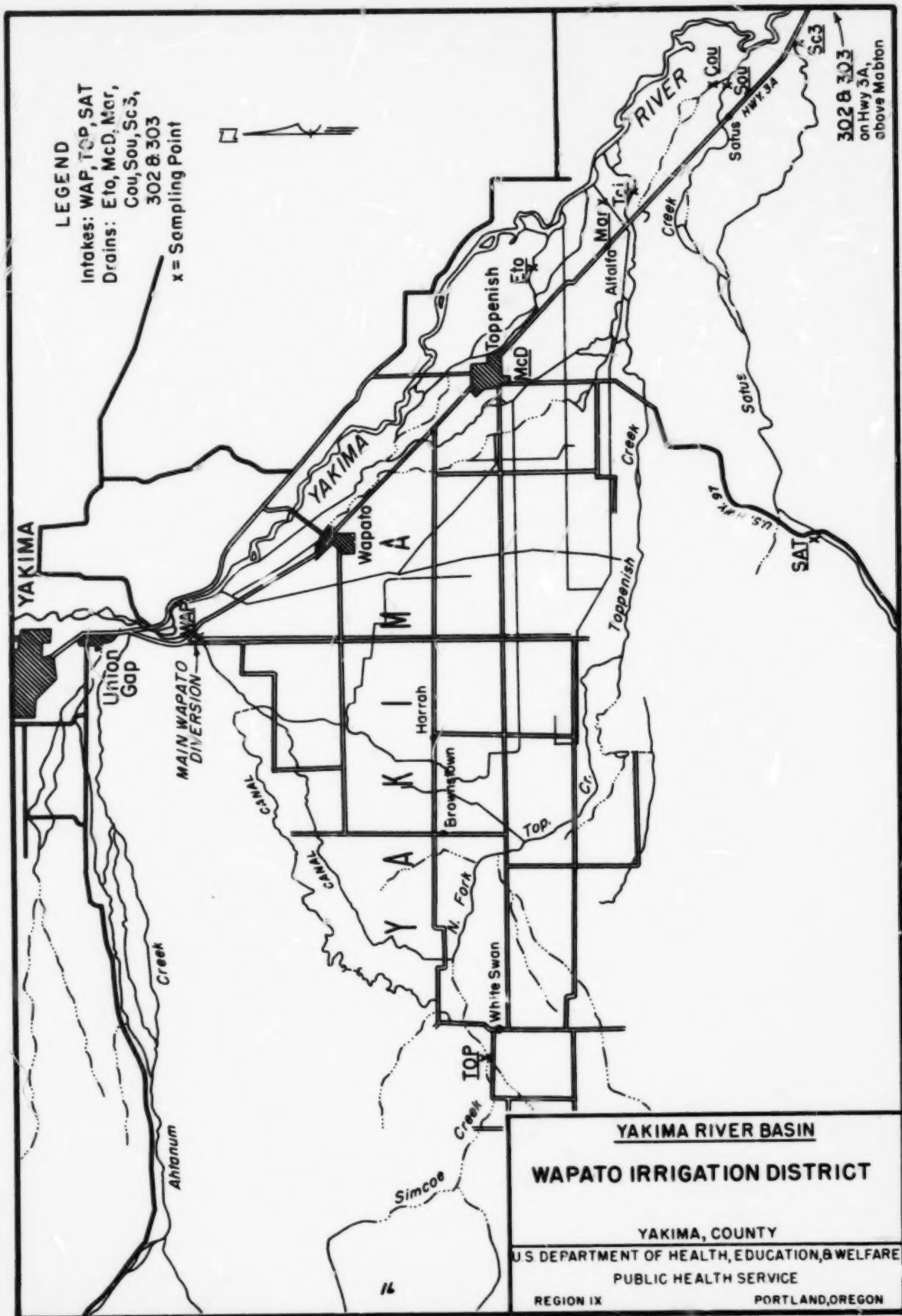


TABLE 2
TABULATIONS OF DATA FROM LABORATORY ANALYSES

Footnotes

* ug/l

** There is a **I** mark between Sou and Cou, which may indicate that these stations are reversed.

count/100 ml

Pesticides - nil - method's sensitivity around 50 ppt.
nil to trace - slight indication but too low to be certain or measured.
possible trace - often found to be nil after repeated analysis with column purification. Also, often not enough sample to repeat analysis.

BOD reading for 11/12/63 is for 7-day instead of usual 5-day period.

- Indicates no test was run, usually due to:

- (1) No water
- (2) Lack of sufficient sample
- (3) Sample lost in transit
- (4) Sample not collected
- (5) Bacteriological samples run by Washington State Pollution Control Commission
- (6) Bacteriological samples shipped to Portland but were more than 24 hours old.

NAPATO IRRIGATION DISTRICT
Station Code: WAP

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	6.6	7.9	1.8	10.4	-	0.06	0.07	2.0	4.0	6.0	5.9	-	44	94 35
4/24/63	7.3	8.5	1.5	8.5	0.10	0.03	0.07	1.4	nil	5.0	5.7	-	36	109 5
5/27/63	-	12.5	0.5	6.7	0.13	0.04	0.19	1.0	3.0	4.0	3.6	-	26	20 26
6/17/63	6.9	17.5	1.2	16.3	-	nil	0.05	2.0	4.0	5.0	4.3	-	36	70 22
7/1/63	6.8	17.0	1.4	2.4	0.04	0.26	0.07	2.0	4.0	8.0	5.5	1.3	38	80 10
7/15/63	7.0	16.1	1.8	7.0	0.02	0.06	0.07	1.7	3.5	3.5	7.6	1.0	40	108 8
8/19/63	7.2	20.0	1.1	6.7	nil	0.19	0.07	1.6	2.3	4.0	5.5	1.3	42	132 24
9/9/63	7.2	15.6	2.4	3.3	0.08	0.22	0.11	2.2	3.3	1.0	7.2	1.5	48	82 24
9/23/63	6.8	16.0	nil	14.9	nil	0.06	0.09	1.9	5.2	4.5	-	-	53	108 14
10/14/63	7.6	15.0	1.8	5.8	nil	0.10	0.18	2.9	5.6	2.0	8.2	2.0	61	100 6
11/12/63	Sample lost in transit													
1/15/64	No water -													
Minimum	6.6	7.9	nil	2.4	nil	nil	0.05	1.4	nil	1.0	3.6	1.0	26	20 5
Maximum	7.6	20.0	2.4	16.3	0.13	0.26	0.19	2.9	5.6	8.0	8.2	2.0	61	132 35
Average	7.0	-	1.4	8.2	0.04	0.09	0.10	1.9	3.5	4.1	5.5	1.0	42	90 17

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*	Coliforms#	
			DDT	Other		Total	Fecal
4/16/63	-	-	nil	nil	-	1,800	-
4/24/63	-	-	trace	nil	0.33 0.30	-	-
5/27/63	5	-	75 ppt	nil	0.06 0.10	1,260	-
6/17/63	-	-	nil	nil	0.001 0.007	6,400	-
7/1/63	5	-	50 ppt	nil	0.0001 0.00018	2,300	-
7/15/63	5	-	nil	nil	0.00055 0.00045	10,600	-
8/19/63	5	-	nil	nil	0.00714 0.01301	22,000	900
9/9/63	5	-	nil	nil	0.00122 0.00143	21,000	6,500
9/23/63	10	-	nil	nil	0.00282 0.00115	200,000	-
10/14/63	10	-	nil	may be trace Heptachlor & Heptachlor epoxide	0.00474 0.00099	18,000	2,000
11/12/63	Sample lost in transit						
1/15/64	No water						
Minimum	5	-	nil	nil	0.0001 0.00018	1,260	900
Maximum	10	-	75 ppt	trace	0.33 0.05	200,000	6,500
Average	6	-	-	-	0.04528 0.01257	31,484	3,133

WAPATO IRRIGATION DISTRICT
Station Code: TOP

TABLE 2 - Page 2

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hard- ness*	Solids*	
														Total	Susp.
4/15/63	8.1	7.6	0.5	8.5	0.11	0.05	0.12	1.0	nil	5.0	4.1	-	47	99	23
4/24/63	6.9	6.5	0.3	7.5	0.12	nil	0.12	0.6	nil	3.0	4.1	-	40	104	nil
5/27/63	-	10.8	0.1	4.2	0.06	nil	0.79	0.5	1.5	1.0	5.2	-	44	98	6
6/17/63	6.8	12.0	1.4	19.2	nil	nil	0.10	2.1	nil	1.0	5.6	-	41	102	nil
7/1/63	6.8	12.0	0.9	4.4	0.02	0.01	0.11	0.7	nil	2.0	5.5	1.8	40	101	13
7/15/63	6.8	11.1	1.2	3.7	nil	0.05	0.12	0.6	2.3	1.5	9.0	2.1	46	161	1
8/19/63	7.0	14.5	0.8	6.3	0.08	0.54	0.16	0.8	0.4	2.5	6.5	2.5	52	162	10
9/9/63	6.8	15.6	1.4	4.9	0.05	nil	0.08	0.7	0.7	5.5	7.5	2.6	52	147	1
9/23/63	6.8	14.0	1.4	9.9	nil	0.04	0.10	0.5	1.1	11.5	-	-	51	152	27
10/14/63	6.8	11.0	1.0	4.4	0.02	0.04	0.16	0.5	2.0	5.0	5.5	2.2	52	95	9
11/12/63	-	9.0	0.8	5.3	0.04	0.01	0.08	1.2	nil	1.0	6.2	1.6	50	95	nil
1/15/64	-	7.0	0.4	3.0	0.03	nil	0.08	0.2	1.2	3.0	6.2	2.2	46	112	3
Minimum	6.8	6.5	0.1	3.0	nil	nil	0.08	0.2	nil	1.0	4.1	1.6	40	95	nil
Maximum	8.1	15.6	1.4	19.2	0.12	0.54	0.79	2.1	2.3	11.5	9.0	2.6	52	162	27
Average	7.0	-	0.9	6.7	0.04	0.06	0.16	0.8	0.8	3.4	5.5	1.3	47	120	8

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms*		
			DDT	Other	A	B	Total	Total	Fecal
4/15/63	-	-	nil	nil	-	-	-	50	-
4/24/63	-	-	trace	nil	0.02	0.02	0.04	-	-
5/27/63	5	-	<50 ppt	nil	0.04	nil	0.04	200	-
6/17/63	-	-	nil	nil	0.0004	0.003	0.0034	4,500	-
7/1/63	(5-0)	-	200 ppt	nil	0.00011	0.00007	0.00014	76,000	-
7/15/63	5	-	nil	nil	0.00023	0.00014	0.00036	9,100	-
8/19/63	10	-	nil	nil	nil	nil	nil	43,000	230
9/9/63	5	-	nil	nil	0.00093	0.00091	0.00184	5,700	1,800
9/23/63	10	-	nil	possible trace	0.00036	nil	0.00036	15,000	380
10/14/63	15	-	nil	Chlordane & Dieldrin	0.00057	0.00034	0.00091	1,000	340
11/12/63	25	-	nil	nil	-	-	-	-	-
1/15/64	-	61	nil	nil	-	-	-	-	-
Minimum	(5-0)	61	nil	nil	nil	nil	nil	50	230
Maximum	25	61	200 ppt	possible trace	0.04	0.02	0.04	76,000	1,800
Average	10	-	-	-	0.00695	0.00271	0.00966	17,172	688

WAPATO IRRIGATION DISTRICT
Station Code: SAT

TABLE 2 - Page 3

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	8.1	9.3	0.7	9.8	0.08	0.05	0.08	1.0	nil	6.0	3.7	-	35	88 19
4/24/63	-	-	0.7	6.2	0.14	nil	0.13	0.7	nil	7.0	4.5	-	34	94 nil
5/27/63	-	13.0	0.7	6.3	0.14	0.01	0.24	0.6	nil	2.0	3.8	-	26	68 12
6/17/63	6.8	18.0	0.8	18.1	0.03	nil	0.08	0.9	0.5	1.0	5.4	-	35	88 nil
7/1/63	7.2	16.0	0.8	0.8	nil	0.03	0.06	0.7	nil	1.0	4.9	1.2	36	92 nil
7/15/63	7.0	17.8	1.1	5.8	0.01	0.05	0.10	0.7	nil	1.0	8.4	1.5	41	138 nil
8/19/63	7.2	17.0	0.4	6.7	0.01	3.06	0.02	0.8	0.3	1.5	6.5	1.5	47	137 15
9/9/63	7.0	21.2	1.8	4.4	0.04	nil	0.06	0.9	0.5	1.0	7.4	2.1	50	106 12
9/23/63	7.2	17.0	0.5	7.0	nil	0.02	0.05	0.7	0.4	1.0	-	-	46	94 nil
10/14/63	7.8	12.0	1.0	4.3	0.01	0.02	0.11	0.9	1.0	1.5	6.0	1.3	48	88 3
11/12/63	-	14.0	3.9	6.7	0.01	2.00	1.53	4.6	7.0	4.0	12.6	2.9	120	193 nil
1/15/64	-	2.0	0.2	2.0	0.03	nil	0.02	2.3	2.1	1.0	6.4	1.7	46	94 nil
Minimum	6.8	2.0	0.2	0.8	nil	nil	0.02	0.7	nil	1.0	3.7	1.2	26	68 nil
Maximum	8.1	21.2	3.9	18.1	0.14	3.06	1.53	4.6	7.0	7.0	12.6	2.9	120	193 19
Average	7.3		1.1	6.5	0.04	0.44	0.21	1.2	1.0	2.3	6.3	1.4	47	107 5

Sample Date	Color	HCO ₃ *	DDT	Pesticides Other	Chlorophyll* A	B	Total	Coliforms* Total	Fecal
4/15/63	-	-	0.9 ppb.	nil	-	0.57	-	< 4	-
4/24/63	-	-	trace	nil	0.32	nil	0.89	-	-
5/27/63	5	-	110 ppt.	nil	0.04	0.002	0.02	210	-
6/17/63	-	-	nil	nil	0.001	0.00009	0.004	5,500	-
7/1/63	5	-	trace	nil	0.00005	0.00032	0.00014	3,700	-
7/15/63	15	-	nil	nil	0.00032	0.0109	0.00065	6,400	-
8/19/63	20	-	nil	nil	0.00390	0.00143	0.01498	31,000	690
9/9/63	15	-	nil	nil	0.00122	nil	0.00265	19,000	300
9/23/63	15	-	nil	nil	0.00054	0.00045	0.00054	800	160
10/14/63	20	-	nil	nil	0.00101	-	0.00146	800	40
11/12/63	20	-	nil	nil	-	-	-	-	-
1/15/64	< 5	57	nil	trace - unknown	-	-	-	-	-
Minimum	< 5	57	nil	nil	0.00005	nil	0.00014	210	40
Maximum	20	57	110 ppt.	trace - unknown	0.32	0.57	0.89	31,000	690
Average	13				0.04089	0.06504	0.10382	7,490	298

WAPATO IRRIGATION DISTRICT
Station Code: Eto

TABLE 2 - Page 4

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	7.9	14.8	2.8	10.6	0.75	-	-	4.0	-	-	-	-	119	-
4/24/63	7.0	12.0	2.4	10.0	0.07	0.56	0.42	3.0	2.0	7.0	8.7	-	85	143
5/27/63	-	17.0	1.1	9.7	0.45	1.10	0.71	3.4	7.0	11.0	10.8	-	94	166
6/17/63	6.8	18.0	1.9	20.2	0.24	0.86	0.54	4.2	7.5	9.0	11.6	-	88	164
7/1/63	6.8	18.0	2.0	5.2	0.23	1.22	0.43	3.5	6.0	10.0	10.4	2.5	92	180
7/15/63	6.8	16.7	2.0	8.0	0.17	1.30	0.34	3.7	6.0	7.5	12.9	2.3	94	203
8/19/63	6.8	18.0	3.0	9.0	nil	4.06	0.36	4.5	5.2	4.0	12.2	2.8	111	218
9/9/63	6.8	19.0	-	7.6	2.65	1.31	0.72	-	6.1	3.5	13.2	2.5	117	196
9/23/63	6.8	17.0	2.5	7.1	nil	1.43	0.41	4.3	7.1	40.0	-	-	111	188
10/14/63	7.2	16.0	1.6	5.2	nil	1.54	0.96	4.8	8.3	5.0	11.2	2.6	113	184
11/12/63	-	13.0	1.6	4.5	0.01	1.66	0.14	6.2	11.0	7.5	11.7	2.8	123	223
1/15/64	-	11.0	2.1	7.0	0.02	1.07	2.25	5.1	8.6	3.0	14.2	3.1	117	192
Minimum	6.8	11.0	1.1	4.5	nil	0.56	0.14	3.0	2.0	3.0	8.7	2.3	85	143
Maximum	7.9	19.0	3.0	20.2	2.65	4.06	2.25	6.2	11.0	40.0	14.2	3.1	123	223
Average	7.0	-	1.0	8.7	0.38	1.46	0.66	4.2	6.8	9.8	11.7	2.7	105	187

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*	Coliforms*	
			DDT	Other		Total	Fecal
4/15/63	-	-	nil	nil	-	130	-
4/24/63	-	-	trace	nil	-	-	-
5/27/63	5	-	150 ppt.	nil	0.10	13,000	-
6/17/63	-	-	nil	nil	0.001	49,000	-
7/1/63	10	-	nil	nil	0.0007	280,000	-
7/15/63	nil	-	about 50 ppt.	nil	0.00065	82,000	-
8/19/63	5	-	nil	nil	0.00859	150,000	60,000
9/9/63	10	-	350 ppt.	nil	0.00121	250,000	125,000
9/23/63	10	-	nil	trace Heptachlor indicated	0.00036	180,000	67,000
10/14/63	10	-	nil	60-80 ppt. Heptachlor indicated	0.00177	24,000	8,000
11/12/63	20	-	nil	nil	-	-	-
1/15/64	<5	130	nil	trace Heptachlor indicated	-	-	-
Minimum	nil	130	nil	nil	0.00036	130	8,000
Maximum	20	130	350 ppt.	trace indicated	0.1	280,000	125,000
Average	7	-	-	-	0.01428	114,237	65,000

WAPATO IRRIGATION DISTRICT
Station Code: McD

TABLE 2.- Page 5

Station Code: MCD

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total	Susp
4/15/63	8.1	14.0	1.3	9.6	0.18	0.82	0.08	5.0	8.0	5.0	9.8	-	100	162	51
4/24/63	7.0	12.5	1.3	9.4	0.07	0.63	0.05	4.9	3.0	3.0	10.4	-	96	141	83
5/27/63	-	17.0	1.5	9.7	0.19	0.91	0.24	5.5	9.0	4.0	11.6	-	100	182	26
6/17/63	6.8	18.5	2.4	22.4	0.03	0.72	0.22	15.2	8.5	5.0	17.6	-	102	199	17
7/1/63	7.0	18.0	1.8	4.2	0.01	1.42	0.24	3.8	8.0	8.0	11.5	2.8	104	194	10
7/15/63	7.0	17.8	1.6	5.3	0.02	1.24	0.30	5.7	7.5	8.0	15.5	3.2	109	229	25
8/19/63	7.0	17.0	2.0	6.2	nil	1.86	0.14	5.8	6.7	9.0	12.2	3.1	113	198	28
9/9/63	7.0	21.2	1.7	3.9	0.07	0.98	0.05	2.6	7.4	2.0	13.8	2.9	114	197	23
9/23/63	7.0	17.0	2.8	6.9	0.02	1.02	0.27	5.4	8.4	1.0	-	-	115	194	12
10/14/63	7.3	16.0	0.9	3.9	0.10	1.29	0.18	4.9	8.3	3.6	10.4	2.6	112	184	9
11/12/63	-	14.0	3.5	3.6	nil	1.72	0.35	3.6	10.0	4.0	17.0	3.9	136	226	8
1/15/64	-	10.0	0.8	6.0	0.02	1.31	0.05	6.5	10.7	6.0	12.9	2.8	123	230	27
Minimum	6.8	10.0	0.8	3.5	nil	0.63	0.05	2.6	3.0	1.0	9.8	2.6	96	141	8
Maximum	8.1	21.2	3.5	22.4	0.19	1.72	0.35	15.2	10.7	9.0	17.6	3.9	136	230	83
Average	7.2	1.8	7.6	0.05	1.16	0.18	5.7	8.0	4.9	13.0	3.0	110	195	27	

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms*		
			DDT	Other	A	B	Total	Total	Fecal
4/15/63	-	-	nil	nil	-	-	-	420	-
4/24/63	-	-	trace	nil	0.18	0.11	0.29	-	-
5/27/63	45	-	175 ppt	nil	0.06	0.04	0.1	3,900	-
6/17/63	-	-	nil	nil	0.001	0.006	0.007	sample lost	-
7/1/63	10	-	nil to trace	nil	0.00128	0.0015	0.00278	65,000	-
7/15/63	15	-	100 ppt	nil	0.00033	0.00032	0.00065	21,000	-
8/19/63	10	-	nil	nil	0.00714	0.01301	0.02016	39,000	25,000
9/9/63	10	-	nil	nil	0.00093	0.00091	0.00184	17,000	3,800
9/23/63	10	-	nil	nil	0.00101	0.00025	0.00126	16,000	2,700
10/14/63	10	-	nil	nil	0.0019	0.00067	0.00257	2,500	870
11/12/63	15	-	nil	nil	-	-	-	-	-
1/15/64	45	123	nil	nil	-	-	-	-	-
Minimum	45	123	nil	nil	0.00033	0.00025	0.00065	420	870
Maximum	15	123	175 ppt	nil	0.18	0.11	0.29	65,000	25,000
Average	10	-	-	nil	0.02817	0.01918	0.04736	20,602	8,093

WAPATO IRRIGATION DISTRICT
Station Code: Mar

TABLE 2 - Page 6

Sample Date	pH	Temp. °C	BOD*	COD*	NH* 3	NO* 3	PO* 4	Cl*	SO* 4	Turb.	Na*	K*	Hard- ness*	Solids* Total	Susp.
4/15/63	8.1	11.7	1.8	8.6	0.14	0.42	0.15	3.0	7.5	4.0	12.1	-	85	158	28
4/24/63	7.1	11.0	1.2	8.8	0.06	0.40	0.06	3.0	2.0	5.0	13.4	-	81	168	8
5/27/63	-	15.5	0.8	4.0	0.14	0.86	0.27	3.0	11.0	4.0	15.4	-	93	186	14
6/17/63	7.4	19.0	1.3	13.0	0.03	0.47	0.24	2.9	8.3	3.0	16.8	-	100	172	14
7/1/63	7.4	18.0	1.7	4.6	nil	1.00	0.23	2.9	8.0	10.0	14.5	3.2	112	186	30
7/15/63	7.2	17.8	1.3	3.9	0.04	0.90	0.21	3.4	6.0	4.0	17.4	3.4	103	239	9
8/19/63	7.2	18.0	1.2	3.8	0.07	1.30	0.19	3.1	5.8	5.5	15.6	3.6	118	211	15
9/9/63	7.2	20.1	2.7	3.4	0.11	0.90	0.21	1.6	6.8	2.5	18.7	3.7	117	209	21
9/23/63	7.2	17.0	1.5	5.8	0.03	0.96	0.26	2.3	7.0	2.5	-	-	111	218	20
10/14/63	7.7	15.0	0.8	5.6	nil	1.22	0.27	3.2	9.2	2.7	15.3	3.6	121	206	11
11/12/63	-	9.0	1.0	20.3	0.02	0.12	0.52	18.4	40.0	9.0	52.5	6.1	224	425	18
1/15/64	-	8.0	1.1	5.0	0.02	1.32	0.24	3.8	12.0	6.0	20.3	4.0	131	250	33
Minimum	7.1	8.0	0.8	3.4	nil	0.12	0.06	1.6	2.0	2.5	12.1	3.2	85	158	8
Maximum	8.1	20.1	2.7	20.3	0.14	1.32	0.52	18.4	40.0	10.0	52.5	6.1	224	425	33
Average	7.4		1.4	7.2	0.05	0.82	0.23	4.2	10.3	4.7	19.3	3.9	100	219	18

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms#	
			DDT	Other	A	B	Total	Fecal
4/15/63	-	-	-	-	-	-	690	-
4/24/63	-	-	trace	nil	0.18	0.11	-	-
5/27/63	<5	-	110 ppt	nil	0.06	nil	1,900	-
6/17/63	-	-	nil	nil	0.001	0.006	13,000	-
7/1/63	10	-	170 ppt	nil	0.0035	0.00496	112,000	-
7/15/63	10	-	nil	nil	0.00053	0.00068	23,000	-
8/19/63	10	-	nil	nil	0.0104	0.01561	39,000	2,800
9/9/63	15	-	nil to trace	nil	0.00121	0.00106	2,800	1,300
9/23/63	10	-	nil	nil	0.00358	0.00056	12,000	500
10/14/63	10	-	nil	nil	0.00389	0.00048	2,900	530
11/12/63	60	-	nil	nil	-	-	-	-
1/15/64	<5	152	nil	trace of Dieldrin or foreign matter	-	-	-	-
Minimum	<5	152	nil	nil	0.00053	0.00056	690	500
Maximum	60	152	170 ppt	trace	0.18	0.11	112,000	2,800
Average	15		-	-	0.02934	0.01548	2,303	1,283

WAPATO IRRIGATION DISTRICT
Station Code: Tci

TABLE 2 - Page 7

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total	Susp.
4/15/63	8.2	12.5	1.2	12.5	0.14	0.10	0.25	4.0	8.0	6.0	12.1	-	85	172	26
4/24/63	7.2	14.0	2.1	14.8	0.10	0.04	0.26	5.2	4.0	7.0	19.8	-	96	190	8
5/27/63	-	20.0	0.9	5.9	0.14	0.37	0.29	4.6	12.0	3.0	20.0	-	107	193	9
6/17/63	7.0	22.5	1.4	14.3	0.05	0.17	0.32	5.5	13.0	8.0	23.2	-	114	213	13
7/1/63	7.6	20.0	2.6	7.4	nil	0.29	0.18	5.3	11.0	7.0	19.9	3.0	104	207	11
7/15/63	7.2	21.1	2.0	6.6	0.03	0.21	0.20	6.2	10.0	4.0	26.9	3.9	120	263	7
8/19/63	7.2	20.0	1.4	6.5	0.02	0.35	0.16	5.5	9.3	7.5	23.9	4.1	132	250	30
9/9/63	7.2	18.4	1.4	4.9	0.05	0.52	0.14	2.3	9.0	2.5	23.9	3.8	128	238	24
9/23/63	7.2	19.0	0.6	6.2	0.01	0.75	0.25	3.1	7.7	5.5	-	-	115	208	26
10/14/63	7.7	15.0	1.2	6.4	0.04	0.91	0.33	4.6	11.7	5.0	20.3	3.8	160	232	13
11/12/63	-	10.0	Sample lost in transit	-	-	-	-	-	-	-	-	-	-	-	-
1/15/64	-	2.0	1.1	9.0	0.04	0.29	0.41	13.8	32.8	12.0	45.0	4.5	182	370	28
Minimum	7.0	2.0	0.6	4.9	nil	0.04	0.14	2.3	4.0	2.5	12.1	3.0	85	172	7
Maximum	8.2	22.5	2.6	14.8	0.14	0.91	0.41	19.8	32.8	12.0	45.0	4.5	182	370	30
Average	7.4	-	1.4	8.6	0.05	0.36	0.25	5.5	11.7	5.0	23.5	3.9	122	176	18

Sample Date	Color	HCO ₃ *	Pesticides			Chlorophyll*			Coliforms#	
			DDT	Other		A	B	Total	Total	Fecal
4/15/63	-	-	nil	nil	nil	-	-	-	680	-
4/24/63	-	-	trace	nil	nil	0.17	0.2	0.37	-	-
5/27/63	5	-	<100 ppt	nil	nil	0.04	nil	0.02	70	-
6/17/63	-	-	nil	nil	nil	0.001	0.006	0.007	35,000	-
7/1/63	15	-	100 ppt or less	nil	nil	0.00585	0.00913	0.01497	120,000	-
7/15/63	15	-	nil	nil	nil	0.00088	0.00077	0.00165	46,000	-
8/19/63	15	-	nil	nil	nil	0.0061	0.00714	0.01324	120,000	40,000
9/9/63	10	-	nil	nil	nil	0.00136	0.00169	0.00305	1,800	1,000
9/23/63	10	-	nil	possible trace or interference	nil	0.00419	0.00127	0.00546	19,000	2,400
10/14/63	15	-	nil	nil	nil	0.00326	0.00071	0.00397	3,200	440
11/12/63	Sample lost in transit	-	nil	-	-	-	-	-	-	-
1/15/64	-	218	nil	nil	nil	-	-	-	-	-
Minimum	5	218	nil	nil	nil	0.00088	0.00071	0.00165	70	440
Maximum	15	218	<100 ppt	possible trace	nil	0.17	0.02	0.37	120,000	40,000
Average	12	-	-	-	-	0.02584	0.02519	0.04881	38,417	10,960

WAPATO IRRIGATION DISTRICT
Station Code: Sc3

TABLE 2 - Page 8

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	8.3	9.7	0.8	12.6	0.06	0.02	0.08	1.0	nil	8.0	4.0	-	30	101 80
4/24/63	7.0	10.3	0.4	7.4	0.08	0.01	0.15	1.6	nil	4.0	6.8	-	54	114 nil
5/27/63	-	19.8	1.5	7.4	0.11	0.22	0.29	10.4	22.0	2.0	29.2	-	140	255 15
6/17/63	7.0	22.0	2.0	17.9	-	0.09	0.20	4.8	9.0	12.0	18.0	-	82	149 107
7/1/63	7.6	20.0	1.4	4.4	nil	0.85	0.22	5.1	11.0	8.0	19.9	3.1	112	225 13
7/15/63	7.2	20.0	1.1	4.9	nil	0.63	0.27	5.5	10.0	8.0	24.3	3.5	120	285 41
8/19/63	7.2	18.5	1.0	8.0	nil	1.15	0.30	6.0	11.2	9.0	20.6	3.7	149	282 84
9/9/63	7.0	15.6	1.6	5.2	0.06	0.56	-	2.8	-	7.0	-	-	144	241 47
9/23/63	7.2	19.0	1.6	9.8	nil	0.61	0.29	4.8	11.8	1.0	-	-	132	304 24
10/14/63	7.9	16.0	0.9	7.4	0.07	0.46	0.35	7.6	18.3	4.0	30.0	4.0	142	292 20
11/12/63	-	12.0	Sample lost in transit	Sample lost in transit	-	-	-	-	-	-	-	-	-	-
1/15/64	-	5.0	0.7	4.0	0.02	0.33	0.18	5.9	14.2	4.0	24.3	3.1	121	232 11
Minimum	7.0	5.0	0.4	4.0	nil	0.01	0.08	1.0	nil	1.0	4.0	3.1	30	101 nil
Maximum	8.3	22.0	2.0	17.9	0.11	1.15	0.30	10.4	22.0	12.0	30.0	4.0	149	304 107
Average	7.4	-	1.2	8.1	0.04	0.45	0.23	5.5	10.8	6.1	19.7	3.5	112	226 42

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms*	
			DDT	Other	A	B	Total	Fecal
4/15/63	-	-	nil	nil	-	-	470	-
4/24/63	-	-	trace	nil	0.28	0.52	-	-
5/27/63	5	-	120 ppt	nil	0.06	0.04	270	-
6/17/63	-	-	nil	nil	0.004	0.011	12,000	-
7/1/63	15	-	nil	nil	0.00247	0.0038	122,000	-
7/15/63	10	-	nil	nil	0.00111	0.00091	24,000	-
8/19/63	15	-	nil	nil	0.01507	0.01948	2,000,000	120,000
9/9/63	-	-	nil	nil	Not enough samples	-	2,500	500
9/23/63	15	-	nil	possible trace	0.00459	0.00081	5,000	330
10/14/63	15	-	nil	Chlordane	0.00607	0.00132	1,600	60
11/12/63	Sample lost in transit	-	nil	-	-	-	-	-
1/15/64	-	148	nil	nil	-	-	-	-
Minimum	5	148	nil	nil	0.00111	0.00081	470	60
Maximum	15	148	120 ppt	possible trace	0.28	0.52	2,000,000	120,000
Average	13	-	-	-	0.04416	0.07467	340,871	30,222

WAPATO IRRIGATION DISTRICT

Station Code: Sou

TABLE 2 - Page 9

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₄ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hard-ness*	Solids* Total	Susp.
4/15/63	8.1	12.5	0.6	8.8	0.15	0.07	0.23	6.0	18.0	8.0	17.0	-	79	187	90
4/24/63	7.5	-	0.8	9.8	0.06	0.02	0.27	6.0	8.0	9.0	20.4	-	84	213	105
** 5/27/63	-	18.5	1.2	10.3	0.18	0.91	0.30	5.1	15.0	6.0	21.2	-	122	230	44
6/17/63	7.0	22.0	1.3	18.9	0.04	0.48	0.45	1.7	20.0	60.0	25.6	-	120	226	24
7/1/63	7.4	20.0	Sample lost in transit	-	-	-	-	-	-	-	-	-	-	-	-
7/15/63	7.4	21.1	1.8	6.6	0.13	0.60	0.35	4.8	10.0	11.5	30.9	4.1	132	393	151
8/19/63	7.6	20.8	1.2	7.1	0.02	2.33	0.33	7.1	7.8	9.5	25.1	3.8	144	302	56
9/9/63	6.8	21.2	0.9	3.9	0.05	0.87	0.22	2.3	8.0	1.0	24.1	3.7	145	248	6
2/23/63	7.2	19.0	1.2	5.8	nil	0.96	0.22	3.1	9.9	4.0	-	-	136	238	12
10/14/63	7.4	16.0	1.0	6.4	0.07	1.21	0.29	4.7	13.0	4.7	22.2	3.7	144	234	4
11/12/63	-	12.0	Sample lost in transit	-	-	-	-	-	-	-	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Minimum	6.8	12.0	0.6	3.9	nil	0.02	0.22	1.7	7.8	1.0	17.0	3.7	79	187	4
Maximum	8.1	22.0	1.8	18.9	0.18	2.33	0.45	7.1	20.0	60.0	30.9	4.1	145	393	151
Average	7.4	-	1.1	8.6	0.08	0.82	0.29	4.5	12.2	12.6	23.3	3.8	123	252	55

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*			Coliforms#	
			DDT	Other	A	B	Total	Total	Fecal
4/15/63	-	-	nil	nil	-	-	-	120	-
4/24/63	-	-	trace	nil	0.08	0.15	0.23	-	-
** 5/27/63	10	-	50 ppt	nil	0.13	0.08	0.21	1,600	-
6/17/63	-	-	nil	nil	0.001	0.006	0.007	48,000	-
7/1/63	Sample lost in transit	-	-	-	-	-	-	250,000	-
7/15/63	10	-	nil	nil	0.00053	0.00068	0.0012	47,000	-
8/19/63	20	-	57 ppt	nil	0.00324	0.00193	0.00518	80,000	50,000
9/9/63	15	-	nil	nil	0.00047	0.00045	0.00092	1,200	200
9/23/63	10	-	nil	possible trace	0.00221	0.00044	0.00265	9,000	500
10/14/63	15	-	nil	Dieldrin	0.00579	0.00115	0.00694	1,200	240
11/12/63	Sample lost in transit	-	-	nil	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-	-
Minimum	10	-	nil	nil	0.00047	0.00044	0.00092	120	200
Maximum	20	-	57 ppt	possible trace	0.13	0.15	0.23	250,000	50,000
Average	14	-	-	-	0.02790	0.03008	0.05798	48,680	12,735

WAFATO IRRIGATION DISTRICT
Station Code: Coa

TABLE 2 - Page 10

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
4/24/63	8.2	-	5.2	24.9	0.42	0.02	0.19	4.4	4.0	6.0	20.8	-	128	211
** 5/27/63	-	20.5	0.6	13.2	0.29	0.19	0.51	9.6	36.0	20.0	34.8	-	126	232
6/17/63	6.8	20.0	1.3	13.8	-	0.94	-	6.6	-	8.0	-	-	135	252
7/1/63	7.2	19.0	1.4	4.2	nil	1.04	0.22	4.6	10.5	8.0	20.3	3.6	125	246
7/15/63	7.2	20.0	3.0	11.5	0.01	0.64	0.27	7.2	18.0	39.0	24.7	3.5	130	284
8/19/63	7.0	20.0	1.6	4.6	0.03	2.81	0.19	4.3	8.4	9.5	28.3	4.9	136	259
9/9/63	No sample received.	-	-	-	-	-	-	-	-	-	-	-	-	-
9/23/63	7.6	18.0	1.4	8.4	nil	0.76	0.49	7.7	40.0	8.0	-	-	165	362
10/14/63	8.1	16.0	1.9	10.0	0.01	0.21	0.70	0.8	116.0	4.6	84.8	8.4	277	572
11/12/63	-	11.0	0.7	10.0	0.02	0.33	0.96	4.8	130.0	2.0	96.0	11.5	317	636
1/15/64	-	6.0	0.6	8.0	0.03	0.26	0.68	25.1	120.0	-	88.0	8.3	276	580
Minimum	6.8	6.0	0.6	4.2	nil	0.02	0.19	0.8	4.0	2.0	20.3	3.5	125	211
Maximum	8.2	20.5	5.2	24.9	0.42	2.81	0.96	25.1	130.0	39.0	96.0	11.5	317	636
Average	7.4	-	1.8	10.9	0.09	0.72	0.47	7.5	33.7	11.7	49.7	6.7	182	363

Sample Date	Color	HCO ₃ *	Pesticides			Chlorophyll*			Coliforms*	
			DDT	Other		A	B	Total	Total	Fecal
4/15/63	No water	-	-	-	-	-	-	-	-	-
4/24/63	-	-	-	-	-	-	-	-	-	-
** 5/27/63	15	-	<50 ppt	nil	nil	0.06	0.04	0.1	2,700	-
6/17/63	-	-	nil	nil	nil	-	-	-	85,000	-
7/1/63	15	-	<50 ppt	nil	nil	0.00078	0.00114	0.00191	93,000	-
7/15/63	15	-	nil	nil	nil	0.00184	0.00195	0.00379	180,000	-
8/19/63	15	-	55 ppt	nil	nil	0.00286	0.0052	0.00806	70,000	30,000
9/9/63	No sample received	-	-	possible trace	-	-	-	-	-	-
9/23/63	20	-	nil	nil	nil	0.00188	0.00008	0.00213	10,000	1,400
10/14/63	20	-	nil	nil	nil	0.0118	0.00168	0.01348	5,300	730
11/12/63	35	-	nil	nil	nil	-	-	-	-	-
1/15/64	13	298	nil	nil	nil	-	-	-	-	-
Minimum	13	298	nil	nil	nil	0.00078	0.00025	0.00191	2,700	730
Maximum	35	298	55 ppt	possible trace	-	0.06	0.04	0.1	180,000	30,000
Average	19	-	-	-	-	0.01323	0.00837	0.02156	64,286	10,710

WAPATO IRRIGATION DISTRICT
Station Code: 302

TABLE 2 - Page 11

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	Sol. PO ₄ *	Cl*	SD ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp.
4/15/63	8.2	14.2	0.6	12.7	0.04	0.06	0.19	1.0	nil	40.0	5.2	-	49	108 809
4/24/63	7.0	-	1.4	23.7	0.25	nil	0.22	1.0	nil	132.0	5.7	-	64	435 337
5/27/63	-	23.8	1.2	23.0	0.28	0.17	0.42	2.6	8.0	75.0	12.4	-	74	52 1200
6/17/63	7.2	25.5	1.9	22.6	0.10	0.48	0.39	4.4	11.0	95.0	18.0	-	111	242 652
7/1/63	7.8	26.0	2.9	8.2	0.06	0.60	0.27	3.5	14.0	80.0	16.2	3.6	105	221 333
7/15/63	8.0	25.0	3.5	10.0	0.11	0.62	0.34	4.3	8.0	55.0	21.8	4.3	110	277 245
8/19/63	8.0	21.3	2.4	8.8	0.01	1.46	0.29	3.8	8.1	13.0	17.4	4.4	122	205 157
9/9/63	No sample received	-	-	-	-	-	-	-	-	-	-	-	-	-
9/23/63	8.0	20.0	2.5	9.8	nil	0.56	0.40	3.4	10.9	7.5	-	-	121	270 79
10/14/63	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
11/12/63	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
Minimum	7.0	14.2	0.6	8.2	nil	nil	0.19	1.0	nil	7.5	5.2	3.6	49	52 79
Maximum	8.2	26.0	3.5	23.7	0.28	1.46	0.42	4.4	14.0	132.0	21.8	4.4	122	435 1200
Average	7.7	-	2.1	14.9	0.11	0.49	0.32	3.0	7.5	62.0	13.8	4.1	95	226 477

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms*	
			DDT	Other	A	B	Total	Fecal
4/15/63	-	-	nil	nil	-	-	-	-
4/24/63	-	-	trace	nil	0.1	0.05	0.15	10
5/27/63	20	-	<50 ppt	nil	0.2	0.05	0.25	-
6/17/63	-	-	740 ppt Dieldrin	nil	0.004	0.004	0.012	4,200
7/1/63	15	-	400 ppt	nil	0.00296	0.00373	0.00669	80,000
7/15/63	20	-	1400 ppt	Dieldrin present	0.00176	0.00264	0.00439	105,000
8/19/63	20	-	45 ppt	nil	0.00286	0.0052	0.00806	280,000
9/2/63	No sample received	-	possible trace Dieldrin	-	-	-	-	160,000
9/23/63	25	-	nil	-	0.00206	0.00018	0.00224	10,000
10/14/63	No water	-	-	-	-	-	-	-
11/12/63	No water	-	-	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-
Minimum	15	-	nil	nil	0.00176	0.00018	0.00224	10,000
Maximum	25	-	1400 ppt	740 ppt Dieldrin	0.2	0.05	0.25	280,000
Average	20	-	-	-	0.04480	0.01653	0.06151	104,868

WAPATO IRRIGATION DISTRICT
Station Code: 303

TABLE 2 - Page 12

Sample Date	pH	Temp. °C	BOD*	COD*	NH ₃ *	NO ₃ *	PO ₄ *	Cl*	SO ₄ *	Turb.	Na*	K*	Hardness*	Solids* Total Susp
4/15/63	8.4	13.6	1.2	6.4	0.11	0.03	0.15	2.0	5.0	11.0	6.1	-	52	107 289
4/24/63	6.9	-	0.7	8.0	0.07	0.09	0.14	1.8	2.0	9.0	6.6	-	70	123 7
5/27/63	-	22.3	0.9	12.8	0.21	0.32	0.26	3.0	9.0	50.0	10.8	-	68	76 262
6/17/63	7.4	26.5	1.9	17.4	0.03	1.14	0.36	6.7	31.0	60.0	23.6	-	128	260 88
7/1/63	7.8	22.0	2.2	8.2	0.05	0.97	0.21	3.7	11.0	72.0	16.8	3.6	107	233 261
7/15/63	8.0	22.2	2.5	6.6	nil	0.87	0.24	4.3	11.0	25.0	21.3	3.6	107	295 111
8/19/63	8.0	21.3	2.1	8.4	0.05	3.36	0.28	4.7	13.0	7.0	19.2	4.4	126	209 137
9/9/63	No sample received	-	-	-	-	-	-	-	-	-	-	-	-	-
9/23/63	8.2	20.0	3.4	7.5	0.02	1.22	0.29	4.6	19.7	6.5	-	-	122	272 43
10/14/63	8.4	16.0	1.3	7.0	0.04	2.33	0.21	9.7	52.6	6.4	24.3	3.3	133	264 28
11/12/63	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-	-	-	-	-	-	-
Minimum	6.9	13.6	0.7	6.4	nil	0.03	0.14	1.8	2.0	6.4	6.1	3.3	52	76 7
Maximum	8.4	26.5	3.4	17.4	0.21	2.33	0.36	9.7	52.6	72.0	24.3	4.4	133	295 289
Average	7.9	-	1.8	9.1	0.06	1.14	0.23	4.5	17.1	27.4	15.1	3.7	101	204 136

Sample Date	Color	HCO ₃ *	Pesticides		Chlorophyll*		Coliforms#	
			DDT	Other	A	B	Total	Fecal
4/15/63	-	-	nil	nil	-	-	1,900	-
4/24/63	-	-	nil	trace Aldrin	0.21	0.28	0.49	-
5/27/63	15	-	50 ppt	nil	0.1	0.03	0.13	54,000
6/17/63	-	-	nil	nil	0.001	0.006	0.007	300,000
7/1/63	20	-	140 ppt	nil	0.00318	0.00496	0.00814	300,000
7/15/63	15	-	nil to trace	nil	0.00055	0.00045	0.001	105,000
8/19/63	20	-	nil	nil	0.00714	0.01301	0.02016	79,000
9/9/63	No sample received	-	-	-	-	-	-	12,000
9/23/63	20	-	nil	possible trace	0.00217	0.00077	0.00293	23,000
10/14/63	15	-	nil	trace	0.00734	0.00086	0.0082	3,500
11/12/63	No water	-	-	-	-	-	-	-
1/15/64	No water	-	-	-	-	-	-	-
Minimum	15	-	nil	nil	0.00055	0.00045	0.001	1,900
Maximum	20	-	140 ppt	trace	0.21	0.28	0.49	300,000
Average	18	-	-	-	0.04142	0.042	0.08342	108,300
								1,524